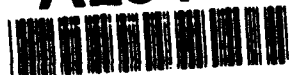


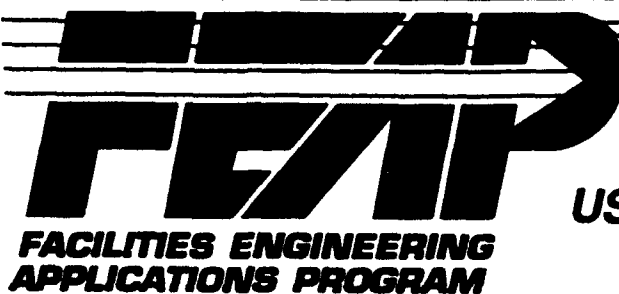
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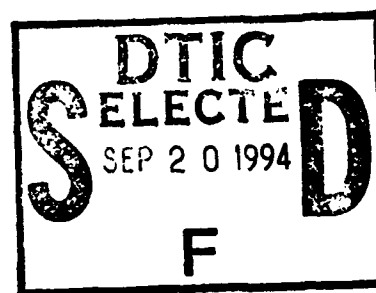
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USER'S GUIDE

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User's Guide: Double Bituminous Surface Treatment



by

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Cutback asphalt cement
Double bituminous surface treatment

Emulsified asphalt cement
Mineral aggregate

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Appendix A: Fact Sheet A1

1 Summary

Description

Double bituminous surface treatment is a term used to describe a common type of pavement surfacing construction which involves two applications of asphalt binder material and mineral aggregate. The asphalt binder material is applied by a pressure distributor, followed immediately by an application of mineral aggregate, and finished by rolling. The process is repeated for the second application of asphalt binder material and mineral aggregate. The first application of aggregate is coarser than the aggregate used in the second application and usually determines the pavement thickness. The maximum size of mineral aggregate used in the second application is about one-half that of the first.

Application

Primarily double bituminous surface treatment is used for surfacing roads and streets, parking areas, open storage areas, and airfield shoulders and overruns. Double bituminous surface treatments are applied to base courses, new pavements, recycled pavements, and worn or aged asphalt pavements. Double bituminous surface treatments resist traffic abrasion and provide a water-resistant wearing cover over the underlying pavement structure. Double bituminous surface treatments add no structural strength to the existing pavement; for this reason, it is not normally taken into account when determining the structural thickness of the pavement.

Benefits

When double bituminous surface treatments are properly designed and constructed, a relatively inexpensive pavement surface can be produced which will provide satisfactory performance for several years with minimum maintenance costs. The double bituminous surface treatment's main function is to provide an all weather, skid-resistant wearing surface that produces a water-resistant layer.

Limitations

Successful application of a double bituminous surface treatment requires the following design and construction considerations.

Construction considerations

Construction of surface treatments should not be carried out during wet or cold weather. Air temperatures should be at least 10°C (50°F in the shade and rising. The first application of asphalt material is intended to bond the cover aggregate to the base or underlying layer. Hot asphalt cement, used on most jobs, attain the temperature of the substrate to which it is applied in a few seconds. If the substrate is cold, the asphalt cement hardens almost immediately and will not grip the aggregate. Asphalt emulsions must "break" or change into asphalt cement by evaporation of the water before it can bond to the cover aggregate. When emulsified asphalt is applied to a substrate that is warm, evaporation takes place quickly. But if the substrate is cold, the evaporation is delayed and it may be hours before the aggregate is bonded.

Design considerations

A double bituminous surface treatment is not a pavement in itself, rather it is a wearing surface that protects the underlying pavement structure from changes in moisture and abrasion by traffic. A double bituminous surface treatment is very thin, varying in thickness up to about 19.0 mm (3/4 in.), it is not intended in itself to increase the strength of the existing pavement or base. Therefore, construction and preparation of an adequate base are essential. The substrate to which the asphalt binder is applied must be hard, free of loose material, and dry for the surface treatment to bond. The amount and viscosity of the asphalt material must be carefully balanced with the size and amount of cover aggregate to assure proper retention of the cover aggregate.

Costs

According to the 1993 Department of the Air Force, Maintenance and Repair Cost and Estimating Guide for Airfield Pavements, double bituminous surface treatment costs for FY 1993 were \$2.76/m² (\$2.31/yd²). Project size is a significant factor in determining the unit price with the larger projects priced in the lower ranges. Local differences in labor, material, transportation, geographic location, or job size may contribute to a range of unit prices for this technology.

Recommendations for Use

Double bituminous surface treatments are recommended for use on primed non-asphalt bases, asphalt base course, or any type of existing pavement. They provide a low cost nearly waterproof, wear-resistant surface that preforms well under medium and low volumes of traffic. This type of surface treatment is also useful as a temporary cover for a new base course that is to be carried through a winter, or for a wearing surface on base courses in planed stage construction.

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2 Preacquisition

Description of Double Bituminous Surface Treatment

Double bituminous surface treatment is a term describing a common type of pavement construction which involves two applications of asphalt binder material and mineral aggregate, usually less than 19 mm (3/4 in.) thick, placed on a prepared surface. The double bituminous surface treatment's main function is to provide an all weather, water-resistant, skid-resistant wearing surface. The asphalt binder material (emulsion, cutback, and asphalt cement) is applied by a pressure distributor, followed by an application of mineral aggregate, and finished by rolling with a rubber-tired roller until the aggregate becomes firmly embedded in the asphalt binder. The process is repeated for the second application of bituminous material and mineral aggregate. The first application of aggregate is coarser than the aggregate used in the second application and usually determines the pavement thickness. The maximum size of mineral aggregate used in the second application is about one-half that of the first. When properly designed and constructed, double bituminous surface treatments provide an economical maintenance and repair tool that is easy to place with a minimum of personnel and is long lasting.

Applications

Double bituminous surface treatments are used for surfacing roads and streets, parking areas, open storage areas, and airfield shoulders and overruns. Double bituminous surface treatments are applied to base courses, new pavements, recycled pavements, and worn or aged bituminous pavements. Double bituminous surface treatments resist traffic abrasion and provide a water-resistant cover over the underlying pavement structure. They add no structural strength to the existing pavement structure but are generally used for one or more of the following purposes:

- a. Double bituminous surface treatments provide wear resistance to newly constructed base courses provided the bases are of good quality and adequate thickness to support the wheel loads to be imposed. If the base course is not covered with a surface treatment, the abrasive action of traffic will reduce the thickness of the base layer, even though the base is properly compacted.
- b. Double bituminous surface treatments are excellent for sealing granular bases, old cracked pavements, and newly constructed open-textured pavements against the entrance of surface water.
- c. Pavements that have become slippery due to bleeding or from the wearing and the polishing of surface aggregates may have skid resistance restored with a double bituminous surface treatment.
- d. A double bituminous surface treatment applied to old, weathered, cracked asphalt concrete pavements that are otherwise structurally sound will stop raveling and disintegrating and seal the cracks.
- e. Other uses of double bituminous surface treatments are to improve night visibility by use of light-reflecting aggregates and to control traffic through lane demarcation by use of aggregates of different color or texture.

Design Methods

Several methods are available for determining the quantities of aggregate and asphalt binder for surface treatments. One method for determining the basic quantities is the test-board method. A board of known area is covered with a sufficient quantity of aggregates, which are placed with their least dimension upward, so that complete coverage of the board with stone, one-stone thick in depth, is obtained. This gives the aggregate spread quantity. Test boards are then sprayed with various quantities of asphalt binder and the binder is covered with the selected amount of aggregate. The aggregate is rolled and the quantity of binder giving optimum embedment of aggregate is selected for design. It is desirable to have about 30 percent voids in the aggregate. The quantities of aggregate and binder determined from the test-board method are adjusted for aggregate whip-off, porosity of the aggregate and base, and the amount of traffic. When liquid and emulsified asphalts are used, the quantity of binder is based on residual asphalt and increased to account for loss by evaporation or volatilization.

Other methods, such as those given by the Asphalt Institute, use surface area formulas for design of aggregate and binder quantities.

None of the design methods are exact, and field test sections are recommended to establish the best application rates. The Corps of Engineers Guide Specification 02555 gives a range of application rates for the asphalt material and covers aggregate for each aggregate gradation specified. These

application rates are based on experience and should produce satisfactory results. This is particularly true when surface treatments are to be applied to old pavements or open-type base courses.

Materials

Aggregate

The degree of wearing resistance, the riding quality, and skid resistance of the surface will be determined primarily by the type of aggregate used in the surface treatment. The minimum amount of cover aggregate to be used should be increased from 5 to 10 percent to take care of whip-off and possible inaccuracies in the spreading operation. If not enough aggregate is placed on the surface, bare spots of asphalt material will be present and may result in low skid resistance, stickiness, and poor abrasion resistance.

The gradation of the aggregate is important and a one-size aggregate is most desirable. The one-size aggregate develops interlocking qualities that are much better than those developed with a well-graded aggregate. Aggregate materials passing the 2.00 mm (No. 10) sieve may act as a filler. Excess filler or fines tend to fall to the bottom of the aggregate layer and become embedded in the surface of the asphalt binder, which prevents a good adhesion and, therefore, causes poor retention of the cover aggregate. Well-graded aggregate may produce rough surfaces and cause a tendency for the larger particles to be torn loose by traffic action, resulting in early deterioration. Large-size aggregates are desirable from the standpoint that good drainage is provided and there is less chance that bleeding will occur. But, large-size aggregate may create a high noise level surface. The shape of the aggregate affects the interlocking qualities of the particles. The best interlocking qualities can be obtained by use of angular particles. When a rounded aggregate is the only material available, crushing is recommended to develop angular surfaces. A large amount of flat and elongated particles is undesirable because such particles may become completely immersed in the asphalt.

Dusty or wet aggregates create a problem because they do not develop a good bond with the asphalt binder material. Small quantities of moisture up to about 1 percent for emulsified asphalt cements do not create a problem, especially in warm dry weather. There are two basic methods of dealing with the problem of dust and moisture. One is washing and drying the aggregate by mechanical means prior to its application. Other methods of improving the adhesion between the aggregate and the asphalt binder consist of coating the aggregate with a very thin film of asphalt called precoating. With this method the aggregate heated to about 93°C (200°F), in an asphalt mixing plant dryer, then mixed in the pugmill with about 1 percent paving grade asphalt cement to coat each particle prior to its application. The precoated aggregate should be free flowing so that it can be applied with an aggregate spreader.

Hard aggregates, such as crushed gravel or quarried stone that do not become polished or crushed under the action of traffic, are the most desirable for best durability and wear resistance. For double bituminous surface treatment use, the abrasion wear should not be more than 40 percent when tested according to the Los Angeles abrasion test, (ASTM C 131).

Asphalt binder materials

The functions of the asphalt binder material are to hold the aggregate in place and bond it to the underlying surface and seal the underlying surface to prevent the entrance of moisture. The asphalt binders generally used for surface treatments are:

- a. *Asphalt cements.* Asphalt cements harden quickly and do not require a curing time. They provide a hard residue with high cohesive strength. Asphalt cements provide an impervious seal and have less tendency to bleed than do other binder types. The disadvantages of asphalt cements are that they require heating to high temperatures, especially if the underlying surface is cold. When the underlying surface is cold, the asphalt cement may chill before the aggregate is bonded. The aggregates must be dry, clean, and be applied before the asphalt cement cools to ambient temperature. Asphalt cements do not penetrate well into old pavements.
- b. *Rapid and medium-curing liquid asphalts.* Rapid-curing liquid asphalts set up rather quickly and provide an impervious, hard residue. Medium-curing liquid asphalts can act as a rejuvenator since the kerosene cutterstock tends to penetrate and soften the old surface. The medium-curing types require longer curing time, but they provide an impervious seal and relatively good cohesion. Laydown and rolling times are less critical with medium-curing asphalts than with the rapid-curing type. Surface treatments using medium-curing asphalts may require several days to cure sufficiently for traffic use. Currently, liquid asphalts are normally not used due to environmental problems, cost, and safety problems (fire hazard).
- c. *Emulsified asphalts.* Emulsified asphalts require little or no heating for pumping in and out of storage containers or for application in the field. Care must be taken so that emulsions do not freeze, since this will cause them to "break" or set up in the storage tank. Emulsified asphalts may be used with damp clean aggregate, set up more quickly than liquid asphalts, and they eliminate the fire hazard that is associated with the use of liquid asphalt. Care must be taken that the cover aggregate is spread immediately after application of the emulsion to ensure proper coating. Anionic emulsions carry a negative charge and therefore, are more attracted to positively charged aggregates, such as limestone and other aggregates composed predominately of calcium minerals. Anionic emulsions may tend to strip from aggregates high in silica, such as chert and quartz gravels. Cationic emulsions are

positively charged and adhere to these negatively charged, hard-to-coat aggregates.

Construction Techniques

Surface preparation

Prior to surface treatment construction, all major defects and unevenness in the existing surface should be corrected. A surface treatment is not a cure for large cracks, potholes, waviness, and extreme roughness, or soft spots. Repair of such irregularities is carried out by removing all loose and defective material to a sufficient depth and replacing it with a suitable patching mixture or base material. A non-asphaltic material should receive an asphalt prime coat prior to application of the surface treatment.

Cleaning of the surface is very important in order to develop a strong bond between the surface treatment and the underlying surface. All foreign materials, such as sand, clay, dust, and other debris, should be removed by use of power brooms or hand brooms or by flushing with water.

Application of asphalt binder material

A truck-mounted or trailer-mounted insulated tank with a positive displacement-type pump, full circulating spray bar, with controls for setting the rate at which the asphalt is applied is desirable. Standard controls on most asphalt distributors include a valve system that governs the flow of material, a pump tachometer or pressure gauge that registers pump output, and a bitumeter with an odometer that includes the number of meters (feet) per minute and the total distance traveled. These types of distributors can provide a steady flow to the spray bar and uniform pressure to the spray bar nozzles. The spray bar and nozzles must be properly adjusted. The angle of the long axis of the nozzle openings must be adjusted so that the spray fans will not interfere with each other. The recommended angle, measured from the spray bar axis, is from 15 to 30 degrees. The height of the spray bar must be such that it produces a double or triple overlap. The best results usually are achieved with double coverage, but triple coverage can sometimes be used with spray bars with 100 mm (4-in.) nozzle spacing. The height of the spray bar must remain constant and parallel to the pavement surface and the spray bar should be adjusted for any crown in the pavement.

It is always advisable to calibrate and check the asphalt distributor to ensure that the specified application rate is obtained. ASTM D 2995 offers a method for determining the application rate of asphalt distributors. In addition, The Asphalt Institutes Manual Series No. 13 offers guidance for calibrating and checking application equipment. A field test section is another method to evaluate the construction techniques and application rates for surface treatment. At least one test section should be constructed before starting surface treatment construction.

Application of aggregate

The aggregate should be applied at the specified rate immediately after application of the bituminous material in order to provide maximum wetting of the aggregate. It should be spread uniformly over the surface at the rate determined for that aggregate. Application is performed by trucks with hopper type tailgate spreaders, trucks with tailgate whirling spreaders, truck-attached mechanical spreaders, and self-propelled mechanical spreaders. The aggregate spreader must be calibrated prior to starting work. The aggregate is always applied ahead of the truck or self-propelled spreader so that the bituminous material is covered with aggregate before the wheels pass over it.

Rolling

Immediately after spreading, the aggregate is rolled to seat the aggregate particles in the asphalt material. Although practice has been to use a steel-wheeled roller followed by a pneumatic-tired roller, it has been found best to use only the pneumatic-tired roller. Pneumatic-tired rollers press the aggregate firmly into the asphalt material without crushing the particles. The tires are able to press the particles into small depressions. Steel-wheeled rollers bridge over depressions and may cause excessive degradation of the aggregate. Rolling is usually performed in the longitudinal direction only, beginning at the outer edges and working toward the center. Rolling should continue until no more aggregate can be worked into the treated surface.

The surface should be swept free of all loose stone using power or rotary brooms 24 hours after completion of rolling and curing because loose unbonded aggregate will degrade under traffic, abrade and loosen otherwise bonded aggregate and, may cause breakage of windshields.

Limitations/Disadvantages

When properly designed and constructed, double bituminous surface treatments can provide an excellent pavement surface. For best results, a clear understanding of its advantages and limitations are essential. A careful study of traffic requirements and an evaluation of the condition of existing materials and pavement structure are vital.

There are two essentials for success with double bituminous surface treatments that are not a part of the surface treatment construction work. The first is favorable weather conditions during construction. Hot, dry weather is required to secure a good job. The air temperature should always be 10°C (50°F) in the shade and rising during double bituminous surface treatment construction. In all designs, the mat, or first course, consists of an application of an asphalt binder material whose function is to bond the cover aggregate to the base. Hot asphalt, used on most jobs attains the surface temperature to which it is applied in a few seconds. If the surface is cold, the asphalt hardens almost immediately and will not grip the aggregate.

Emulsions must "break" or change into asphalt by evaporation of the water and emulsifying agent before the asphalt cement can bond the cover aggregate. When emulsified asphalt is applied to a surface that is warm, this change takes place quickly. But if the surface is cold, the change is delayed and it may be hours before the aggregate is bonded.

The second essential to success with a double bituminous surface treatment is an adequate base. A double bituminous surface treatment does not add to the pavement structure, rather it is a wearing surface that protects the underlying pavement structure from changes in moisture and abrasion by traffic. A double bituminous surface treatment is very thin normally, about 19.0 mm (3/4-in.) in thickness; it is not intended in itself to increase the strength of the pavement structure. Therefore, construction and preparation of an adequate base is essential for a surface treatment to give the service expected.

FEAP Demonstration/Implementation Site

Table 1 FEAP Demonstration/Implementation Site		
Installation	Date	Location
McAlester, OK Army Ammunition Plant	FY 93 and FY 94	Road 5, Stations 0 + 00 to 61 + 91 and 100 + 00 to 254 + 68
		Road 6, Stations 0 + 00 to 213 + 30
		Road 8, Stations 0 + 00 to 158 + 80
		Road F, Stations 0 + 00 to 98 + 00

These existing roads were being reconstructed due to relatively weak subgrade conditions and to reduce the amount of maintenance required for them to remain functional.

Reconstruction techniques

The first step in the reconstruction process was to remove 100 mm (4 in.) of the existing surface. Next, a total of 300 mm (12 in.) of the existing subgrade was lime modified and compacted to at least 95 percent of CE-55 maximum density. To complete the base and subgrade construction, a 200-mm (8-in.) thick stabilized aggregate base course was placed and compacted in two 100-mm (4-in.) thick lifts over the subgrade. The base course was then allowed to cure until the moisture content in the top 50 mm (2 in.) was drier than four percent below the optimum moisture content, as determined by CE-55.

After the final compaction and moisture content and grade requirements for the base course were achieved, the base was prepared for application of the asphalt prime coat. Preparation for priming included a light sweeping with a power broom to clean the surface of loose material and other foreign matter and sprinkling with water immediately prior to application of the asphalt prime coat.

An asphalt prime coat (MC-30) was applied to the prepared base course surface at the rate of 1.22 liters/m² (0.27 gal/yd²) using a truck-mounted pressure distributor. The asphalt prime coat was allowed to cure for a minimum of 48 hr to allow sufficient time for the asphalt prime coat to penetrate into the base course surface and harden.

Prior to applying the asphalt emulsion, the primed base was again swept with a power broom to remove dirt and loose material. The asphalt emulsion (CRS-2S) was applied at the rate of 1.22 liters/m² (0.27 gal/yd²) (the amounts of bituminous binder are amounts of residual asphalt). The asphalt emulsion was applied using a truck-mounted pressure distributor equipped with a valve system to govern the flow of the asphalt emulsion, a tachometer to register the pump output and a bitumeter with an odometer which indicates the number of meters (feet) per minute and the total distance traveled. The height of the spray bar was set to produce a double coverage with the angle of the spray bar nozzle openings at 30 degrees measured from the spray bar axis.

Application of aggregate

The No. 1 cover aggregate was applied using a self-propelled mechanical spreader at the rate of 20 kg/m² (37 lb/yd²) immediately after application of the asphalt emulsion in order to provide maximum wetting of the aggregate.

The contract specifications required the second application of asphalt emulsion and the No. 2 mineral aggregate to be applied in two applications. The asphalt emulsion was applied at the rate of 1.00 liters/m² (0.22 gal/yd²); the No. 2 mineral aggregate was applied at rate of 13.6 kg/m² (25 lb/yd²).

Rolling

Immediately after application of each layer of aggregate, the aggregate particles were seated in the asphalt emulsion using a pneumatic-tired roller followed by a steel-wheeled roller. The steel-wheeled roller was used to give a smoother, more uniform appearance. Rolling was continued until no more aggregate could be worked into the treated surface.

Life-Cycle Costs and Benefits

According to the 1993 Department of the Air Force, Maintenance and Repair Cost and Estimating Guide for Airfield Pavements, asphalt concrete pavement cost \$2.56/m² (\$2.12/yd²). As per The Asphalt Institutes Manual

Series No. 1, titled, Thickness Design-Asphalt Pavements for Highways and Streets (Table VI-3), the minimum thickness of asphalt concrete recommended over untreated aggregate base for light traffic rural roads is 75 mm (3 in.). It is estimated that it would have cost \$7.61/m² (\$6.36/yd²) or \$1,111,728.00 to build an asphalt concrete surfaced pavement structure capable of carrying the same traffic loads at this site. The cost of placing the double bituminous surface treatment was \$447,268.00. This translates into a cost of about \$3.06/m² (\$2.56/yd²) for the double bituminous surface treatment on this job. This resulted in a savings of \$4.55/m² (\$3.80/yd²) or a 60 percent cost savings, using the double bituminous surface treatment option. The elimination of continual maintenance on these roads will result in additional long-term savings for the installation.

Advantages/Benefits

There are many advantages in using a double bituminous surface treatment under certain conditions. Weighing these advantages against the disadvantages of using a double bituminous surface treatment is a much easier task when specific site conditions such as subgrade quality, material availability and cost, and traffic conditions are known. Although certain site conditions may create special benefits for using a double bituminous surface treatment, the following list comprises the major reasons for using a double bituminous surface treatment. Double bituminous surface treatments will:

- a.* Provide an economical pavement wearing surface.
- b.* Provide an abrasive-resistant surface.
- c.* Waterproof the underlying layers.
- d.* Improve skid resistance.
- e.* Rejuvenate old pavements.
- f.* Provide a means of traffic control.

3 Acquisition/Procurement

Potential Funding Sources

Typically, installations fund the implementation of Pavement and Railroad technologies from their annual budgets. However, the annual budget is usually underfunded and normally the Pavement and Railroad projects do not compete well with other high visibility or high interest type projects. As a result, it is in ones' best interest to seek all of the funds possible from other sources when the project merits the action. Listed below are some sources commonly pursued to fund projects.

- a. *Productivity program.* See AR 5-4, Department of the Army Productivity Improvement Program for guidance to determine if the project qualifies for this type of funding.
- b. *Facilities Engineering Applications Program (FEAP).* In the past, a number of Pavement and Railroad maintenance projects located at various installations were funded with FEAP demonstration funds. At the time, emphasis was placed on demonstrating new technologies to the Directorate of Engineering and Housing (DEH) community. Now that these technologies have been demonstrated, the installations will be responsible for funding their projects through other sources. However, emphasis concerning the direction of FEAP may change in the future; therefore, one should not rule out FEAP as a source of funding.
- c. *Special programs.* Examples of these are:
 - (1) FORSCOM mobilization plan which may include rehabilitation or enlargement of parking areas and the reinforcement of bridges.
 - (2) Safety programs which may include the repair of unsafe or deteriorated railroads at crossings and in ammunition storage areas.
 - (3) Security upgrades which may include the repair or enlargement of fencing.

- d. Reimbursable customer.* Examples of this source are roads to special function areas such as family housing or schools and airfield pavements required to support logistical operations.
- e. Special requests from MACOMS.*
- f. Year end funds.* This type of funding should be coordinated with the MACOMS to ensure that the funds will not be lost after a contract is advertised.
- g. Operations and Maintenance Army.* These are the normal funds used for funding pavement and railroad projects.

Technology Components and Sources

Components of this technology which must be procured to construct a double bituminous surface treatment are project design (may be accomplished in-house or contracted out), construction of sublayers, and placement of the double bituminous surface treatment. Contractor or in-house personnel with experience in roadway construction are required in the construction of sublayers and double bituminous surface treatments.

All of the items used in the placement of a double bituminous surface treatment are conventional equipment and procedures that are used by the construction industry. No special materials are required.

Procurement Documents

A Corps of Engineers guide specification and Department of the Army technical manual are available to provide assistance in completing project specifications. The available guidance includes:

- a. CEGS-02555, "Bituminous Surface Treatment."*
- b. Department of the Army and the Air Force TM 5-822-8/AFM 88-6, Chap. 9, "Bituminous Pavements Standard Practice."*
- c. The Asphalt Institute, Manual Series No. 13, "Asphalt Surface Treatments and Asphalt Penetration Macadam."*
- d. The Asphalt Institute, Manual Series No. 19, "A Basic Asphalt Emulsion Manual."*

Procurement Scheduling

Normal construction contract schedules should be established that allow adequate design and plan preparation time; design, review and approval; contract preparation; advertising and award; and construction time. Relatively small projects that require limited plans and specifications can be prepared and ready to go within a few months. Placement of double bituminous surface treatments should be scheduled during the summer or fall of the year.

4 Post Acquisition

Initial Implementation

Equipment

The equipment required for construction of a double bituminous surface treatment is described in Chapter 2. This equipment is standard construction equipment; therefore, no special equipment is required.

Materials

The materials required for construction of a double bituminous surface treatment include the asphalt binder materials and mineral aggregates. The physical properties required for each of these materials are described by respective ASTM Standards, which are referenced in CEGS-02555, "Bituminous Surface Treatment."

Personnel

The personnel should be experienced in the construction of double bituminous surface treatments. At the demonstration site, the work was contracted out. Installation personnel also construct surface treatments as routine maintenance.

Procedure

The general procedure used to construct a double bituminous surface treatment includes the following steps:

- a.* Construct subgrade, subbase, and base course layers in a fashion similar to that used for other flexible pavements.
- b.* Repair all major defects and unevenness in existing pavement.
- c.* Clean surface to be covered with revolving mechanical sweepers or hand brooms or by flushing with water.

- d. Spray asphalt binder material at the specified rate.**
- e. Spread the No. 1 cover aggregate at the specified rate immediately behind the asphalt binder material application to achieve maximum possible wetting of the mineral aggregate.**
- f. Roll mineral aggregate cover to seat particles in the asphalt binder material.**
- g. Repeat steps c. through f. for the second application of mineral aggregates.**

Operation and Maintenance

A double bituminous surface treatment is in itself basically considered a maintenance activity. Surface treatments can last for a considerable time provided they are designed and constructed properly. Surface treatments under light to medium traffic may perform well for 7 to 10 years.

Service and Support Requirements

No special services or support is required to implement or maintain this technology.

Performance Monitoring

Installation personnel can monitor and measure the performance of the double bituminous surface treatment by making periodic inspections of the surface for signs of distress. Typical surface treatment distresses include loss of cover aggregate, cracking, and bleeding.

References

American Society for Testing and Materials. (1973). "Standard test method for resistance to degradation of small-size coarse aggregate by abrasion and impact in the Los Angeles machine," ASTM-C-131, Philadelphia, PA.

_____. "Standard practice for determining application rate of bituminous distributors," ASTM-D-2995, Philadelphia, PA.

Asphalt Institute. (1970). "The asphalt handbook," Manual Series No. 4, College Park, MD.

_____. (1979). "A basic asphalt emulsion manual," Manual Series No. 19, College Park, MD.

_____. (1979). "Asphalt surface treatments and asphalt penetration Macadam," Manual Series No. 13, College Park, MD.

_____. (1981). "Thickness design-asphalt pavements for highways and streets," Manual Series No. 1, College Park, MD.

Department of the Army and the Air Force. (1987). "Bituminous pavements standard practice," TM 5-822-8/AFM 88-6, Chap. 9, Washington, DC.

U.S. Army Corps of Engineers Guide Specification (CEGS) 02555. (1982). "Bituminous surface treatment," Washington, DC.

Appendix A

Fact Sheet

Description of Technology

Double Bituminous Surface Treatment (DBST) is one of several types of asphalt and asphalt-aggregate surface applications. When properly constructed, DBST is an economical maintenance tool that is easy to place with a minimum of personnel and is long lasting. DBST may be applied to base courses, new pavements, worn or aged bituminous pavements, and old portland cement concrete pavements.

Status of Demonstration

McAlester Army Ammunition Plant, McAlester, OK, was selected as the demonstration site for the DBST project. The project was designed by and constructed under the supervision of the Tulsa District, Corps of Engineers. DBST procedures were demonstrated on Road 5, Stations 0+00 to 61+91 and 100+00 to 254+68, Road 6, Stations 0+00 to 213+30, Road 8, Stations 0+00 to 158+80, and Road F, Stations 0+00 to 98+00.

Benefits of Technology

DBST provides an economical long lasting pavement surface that may be used to provide an abrasion-resistant surface, to waterproof the underlying layers, to rejuvenate old weathered pavements, or to improve skid resistance. Other uses may be to improve night visibility by use of light reflecting aggregates, to control traffic through lane demarcation by use of aggregates of different color or texture, and to improve riding qualities and appearance of pavements.

Points of Contact

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